SURVIVAL OF TRANSPLANTED CUPRESSUS IN THE PYGMY FORESTS OF MENDOCINO COUNTY, CALIFORNIA

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In a recent study of the edaphic restriction of *Cupressus* and *Pinus* in central California (McMillan, 1956), certain species from highly acid soils and from serpentine soils were investigated. Soil tolerance studies conducted both under greenhouse conditions and in large outdoor bins were used in this inquiry.

One phase of the investigation not previously reported involved the transplanting of seedling trees to the habitat of the pygmy forest in Mendocino County. At the time of the transplanting no extended analysis of seedling survival was anticipated. Since it has been possible to continue the observations, however, this report will evaluate the survival over a period of seven years.

The pygmy forests have been described adequately elsewhere (McMillan, 1956), but certain features of the transplant site on the coastal plateau between the Little and Albion rivers are pertinent. The transplant area, approximately one mile southwest of the Mendocino County Airport, was on the property of Miss Jean MacGregor Boyd. It had been subjected to previous burnings and was covered by a low growth of trees and shrubs. The site was included within the narrow restriction of both *Cupressus pygmaea* (Lemm.) Sarg. and *Pinus bolanderi* Parl., and both species were represented by numerous individuals varying in height from 25–100 cm. *Vaccinium ovatum* Pursh, *Rhododendron californicum* Hook., and *Gaultheria shallon* Pursh were common shrubs of the area. *Arctostaphylos nummularia* Gray, a species which does not crown-sprout following burning, was represented by a few small shrubs. In adjacent areas with no record of recent burning, *Arctostaphylos* was common with *Pinus muricata* Don. The dense *Sequoia-Pseudotsuga* forest, common on the margins of the plateau, was adjacent to the transplant site. The soil in the transplant garden is a ground-water podsol with a pH of 3.8–4.0. This ashy-colored soil, which is common throughout the areas of the pygmy forest, is usually less than a foot in depth and is one of the most acid soils in California.

Seedlings of the various strains of *Cupressus*, including those of *C. pygmaea*, *C. goveniana* Gord., *C. abramsiana* C. B. Wolf, and *C. sargentii* Jeps., were transplanted from the greenhouse at Berkeley to the pygmy forest in November, 1950. Six of each strain were planted in each of two series. One group was protected from browsing animals by a large wire screen cage, while the second series remained unprotected. The unprotected seedlings were severely damaged and could not be used in the study. The cage protected the other seedlings throughout the investiga-

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tion. Measurements were recorded at intervals beginning at the date of planting and continuing until August, 1957.

In April, 1952, individuals of the two strains of *C. pygmaea* from Mendocino County (one from the pygmy forest area, the other from Anchor Bay) were dark green and vigorous. Individuals of the two strains of *C. goveniana* from Monterey County (one from Huckleberry Hill and the other from behind Point Lobos) and the one strain of *C. abramsiana* (from Bonny Doone in the Santa Cruz Mountains) were lighter green and lacked vigor. The average growth increment since transplanting showed clearly that the *C. pygmaea* strains were the most vigorous even though the actual increase in height for all strains was slight. Seedlings of *C. sargentii* (from a serpentine area on Mt. Tamalpais in Marin County) were barely surviving in 1952.

Over the same two-year period, seedlings were grown at Berkeley in large outdoor bins containing soil from the habitat of the pygmy forests. These bins were used until 1952 and at that time the responses of the strains reversed the trend indicated in the transplant garden. The vigor and height of the two strains of *C. pygmaea* was less than that of either *C. goveniana* or *C. abramsiana*. In contrast, seedlings of all strains grew well at Berkeley in bins containing an agricultural type of soil. The *C. pygmaea* strain from the pygmy forests was extremely vigorous on the agricultural soil and had an average height of 82 cm. after the 2-year growth period (McMillan, 1956). This contrasts sharply with a 3.3 cm. average height increase of the same strain when transplanted to the pygmy forest habitat.

In August, 1954, the transplant garden was observed after an interval of two years. The growth differential which had been apparent in 1952 was intensified. The trees of *C. pygmaea* were much more vigorous than those of either *C. goveniana* or *C. abramsiana*. Of the surviving strains, only that from Pt. Lobos failed to show an increase in height over 1952 measurements. All of the individuals of *C. sargentii,* the only strain from serpentine soils, had died during the interval.

Observations at the transplant garden in August, 1957, indicated considerable development of both strains of *C. pygmaea*. Somewhat greater vigor characterized the individuals of the pygmy forest strain. Average growth since transplanting was 11.8 cm. The average height increase for the Anchor Bay strain was 9.3 cm. These strains of *C. pygmaea* produced pollen-bearing cones and only the pygmy forest strain had produced a mature seed-bearing cone.

Much less growth and a reduction in the number of surviving trees were noted in *C. goveniana* and *C. abramsiana*. None of the trees of the Point Lobos strain of *C. goveniana* survived. The four surviving trees of the Huckleberry Hill strain had grown very slightly and none was vigorous. Only two of the *C. abramsiana* individuals were surviving and these showed only a trace of height increase.

The growth pattern of dwarfed trees of *C. pygmaea* results from a

unique tolerance for the highly acid soils of the pygmy forest area. At the transplant site, small, cone-bearing trees, varying between 25 and 50 cm. in height, had 21 growth rings when measured in 1952. These trees were less than 70 cm. in 1957. Other trees, in pygmy forest areas adjacent to the transplant site, had over 100 growth rings, a 6–10 cm. diameter and a height of less than 2 m. A few larger trees (30–50 m.), such as those measured by Mathews (1929), indicate the type of growth which can be achieved under conditions which support mostly *Sequoia* and *Pseudotsuga*.

Although the survival pattern in *Cupressus* indicates that the strain from the pygmy forests is the best fitted for growth on the highly acid soils in Mendocino County, it must not be inferred that the other strains are incapable of the growth pattern producing a pygmy forest. For example, at Huckleberry Hill, trees of *C. goveniana* closely resemble *C. pygmaea*. Although occasional tall trees of *C. goveniana* occur with *Pinus radiata* Don, the majority of the trees with *P. muricata* give an appearance of a pygmy forest. The inability of the Huckleberry Hill strain to grow well at the transplant garden in Mendocino County is particularly difficult to explain on an edaphic basis because of the marked similarity of the soils of the two areas. Climatic conditions of Mendocino County suggest a more likely explanation. However, trees of *C. macrocarpa*, a species also restricted to the Monterey Peninsula in its natural distribution, are thriving and reproducing along the Mendocino County coast. Unless the climatic tolerances of *C. macrocarpa* and *C. goveniana* differ markedly, the explanation would lie possibly in the action of the highly acid soils in conjunction with the cooler temperatures of the more northern location. Extended periods of freezing temperatures and of dry summer conditions occurred between 1954 and 1957. This may have provided the critical point for reduced survival among all of the strains from the more southerly localities and, in particular, produced conditions beyond the tolerance of the Point Lobos strain of *C. goveniana*. The loss of seedlings of *C. sargentii* early in the study may indicate a low survival potential on highly acid soils by strains from serpentine soils.[1]

Studies of the nature of restriction of *Cupressus pygmaea* indicate that the species is not confined to the pygmy forests because of an inability to grow elsewhere. The restriction results, in part, from the tolerances of *C. pygmaea* for conditions resulting in a dwarfed form and, in part, from the lack of tolerance by taller forms, such as *Sequoia* and *Pseudotsuga*, for growth on the shallow, highly acid soils. Furthermore, these survival studies indicate that *C. pygmaea* possesses a tolerance not shared by the strains of other species of *Cupressus* for conditions of the pygmy forest habitat.

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[1] Preliminary studies indicate that day length factors were not critical in the differential survival of the Huckleberry Hill and Mendocino seedlings. In greenhouse studies, seedlings of the Monterey strain as well as seedlings of both Mendocino strains responded similarly to a range of light periods: 8-hour, 12-hour, and 16-hour.

Selective influences on the coastal plateau of Mendocino County have sorted out a combination of species with unique qualities for survival in one of the most extreme soil situations in California. The pygmy forests which have resulted from this selective action include much of the natural distribution of both *Cupressus pygmaea* and *Pinus bolanderi*. The gigantic *Sequoia-Pseudotsuga* forests which grow in adjacent portions of the coastal plateau present an amazing contrast in vegetational selection.

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AN INTERSPECIFIC CROSS IN CUCURBITA (C. LUNDELLIANA BAILEY × C. MOSCHATA DUCH.)

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As one aspect of a comprehensive study of the origin and relationship of the cultivated species of *Cucurbita*, *C. lundelliana* Bailey, a non-cultivated species, was crossed with *C. moschata* Duch., one of the five cultivated species of the genus. In *Cucurbita* successful crosses between truly wild species and domesticated ones have not been hitherto reported. Essentially the cross *C. lundelliana* × *C. moschata* combines two genotypes, the one (*C. lundelliana*) a wild species and the other (*C. moschata*) with a long history of cultivation. The hybridization experiments reported here were made with the idea that the compatability relations might indicate directions in which to search for the common ancestor of the cultivated group, and perhaps suggest in a general way the area where the cultivated forms were domesticated (Whitaker, 1956). Furthermore, it was thought that the results would contribute to an understanding of the heritability of characters such as large fruit, large seed, soft rind, etc., which have value under cultivation. The results reported here provide partial answers to some of these questions.

Materials and Methods

Cucurbita lundelliana, the Peten gourd, is endemic in Central America. It has been collected in Guatemala, British Honduras, and southern Mexico (Yucatan). The plants are strong, vigorous annuals, with fine,

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